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ABSTRACT

Composting is a way of using organic wastes from yards and kitchens to help plants grow. This book discusses how composting happens in nature, the classification of composting methods, and their characteristics. Examples of containers for aerobic/anaerobic decomposition are introduced along with sample activities. The process of aerobic/anaerobic decomposition and a bird that uses compost are described. (KHR)

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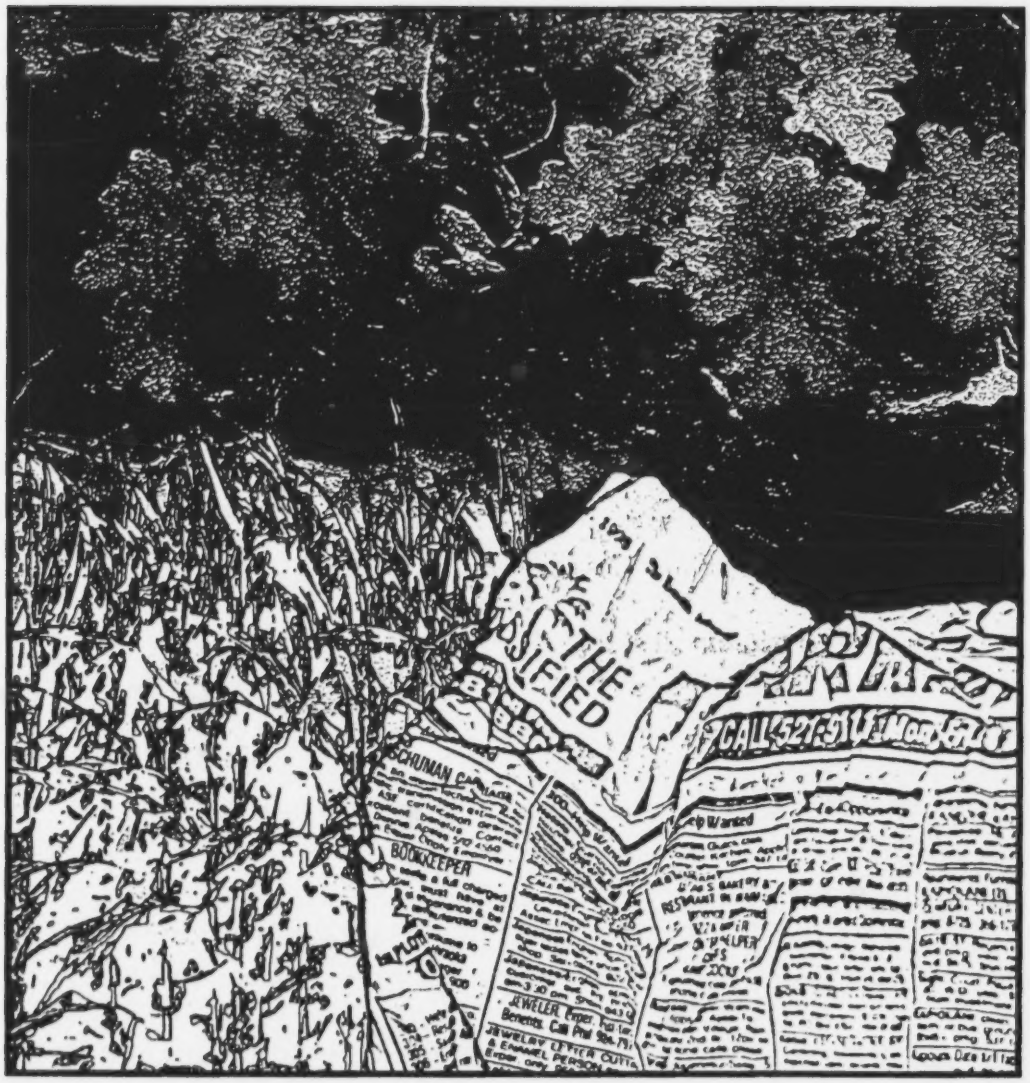

FAST 2

Foundational Approaches in Science Teaching
Curriculum Research & Development Group

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Introduction to Composting

Composting is a way of using organic wastes from yards and kitchens to help plants grow. Composting happens in nature when animal and vegetable matter in swamps and forests and grasslands falls and decays. Bacteria and worms and insects go to work on it, getting energy for their own life processes and releasing nutrients in a form that plants can use.

The product of this natural recycling of matter, called *compost*, is a dark, crumbly, nearly odorless ingredient of rich soil. It softens soil so that plant roots easily penetrate it. And because it holds water, it helps to keep soil moist. Worked into soil, compost enriches it, supplying fertilizer for new plants to grow on.

Composting happened naturally long before people lived on Earth. Eventually someone noticed that crops grew better near piles of rotting matter and figured out how to make composting happen by balancing food, air, and water. This discovery was handed on to generations of descendants.

Clay tablets in Mesopotamia (now Iraq) tell of using compost in agriculture perhaps 4,000 years ago. Israelites mention it in their writings in the Old Testament. Shakespeare had Hamlet advise "do not spread the compost on the weeds, to make them ranker."

In 1905 Sir Albert Howard, an agronomist with the British government, went to India, where he spent 29 years experimenting with ways to make compost. He finally settled on the Indore Method, which calls for three parts of plant material to one part of manure, spread in layers and turned regularly as it decomposed.

In the United States, a young businessman named J. I. Rodale heard about Sir Albert's work. He promptly bought a small farm in Pennsylvania to test Sir Albert's ideas and began corresponding with Sir Albert about organic farming. Rodale started a publishing company, the Rodale Press, and spent

the rest of his life promoting organic farming, nutrition, health, and environmental action.

Not only does using compost rather than chemical fertilizers restore depleted soil without polluting the environment; it is also a good way of reducing household wastes. It is, in fact, so effective that major cities have gone into large-scale composting of garbage. They give or sell the compost to farmers and gardeners for growing new crops.

Methods of Composting

Composting methods fall into two main classes, *aerobic* and *anaerobic.* Aerobic composting requires air; anaerobic composting doesn't. Aerobic composting takes 1 to 3 weeks, and it produces compost with a pleasant, earthy smell. Anaerobic composting takes several months, and the decomposing process smells bad.

Because aerobic composting calls for ample air, the compost pile must be loosened and turned every 2 days. But nutrients—40% to 90%— escape from the pile in the form of gases.

On the other hand, anaerobic composting, in which the compost pile is buried or covered with plastic sheeting to keep air out, vastly reduces the loss of nutrients, but the decomposing pile can stink. Table 1 compares the features of the two main kinds of composting.

Table 1 Comparison of Aerobic and Anaerobic Decomposition

Factor	Aerobic	Anaerobic
Time for completion	7 to 21 days	3 to 4 months
Odor	Odorless	Putrid smell
Turning	Must be turned every 2 days	No turning
Nutrient loss	40% to 90%	2% +
Aeration	Needs constant aeration	Must be kept airtight

The Compost Pile

A compost pile needs a variety of materials so that it will yield the nutrients that plants need. A pile of just one kind of material will not have the needed nutrients, nor will it decompose properly.

Material for the compost pile must be organic—that is, it must come from plants and animals. It should have up to 25% manure by volume, as Sir Albert found in his experiments in India. Manure supplies the nitrogen that sustains the organisms that decompose the materials in the pile.

Plant and animal materials for the compost should be shredded to release fluids and break down tissues. You can use a lawnmower to shred the materials.

Then mix the shredded materials well and wet the pile thoroughly. For good decomposition, the pile should have about 56% moisture content—about as wet as a wrung-out sponge. If the pile starts drying out as the materials decompose, you should add water.

To get vigorous action going in a compost pile, you should have at least .15 to .20 cubic meters (35 to 50 gallons) of mixture per pile.

To summarize, a compost pile should

- contain a mixture of plant and animal materials, shredded
- contain at least 25% of manure to supply nitrogen to organisms
- be as damp as a wrung-out sponge
- have a volume of at least .15 to .20 cubic meters

Preparing Compost

Whether you use an aerobic or an anaerobic method of decomposing your materials, you make your compost pile in the same way. Follow the procedure below.

If you plan to observe the decomposition process, use the procedure in "Studying the Decomposition Process" on pages 12 and 13. If you're making compost only for gardening, you can skip that section.

Materials

- raw materials for composting, such as

grass clippings	any plant or animal matter
weeds	garbage
leaves	small bones
stems	twigs
seeds	sawdust
flowers	straw or hay
seaweed	hair
table scraps	feathers
fruit and vegetable peelings	wool or cotton
coffee grounds	manure

- lawnmower
- 2 to 4 rakes
- 2 to 4 spading forks
- pH paper
- thermometer

Directions

1. Decide whether to use the aerobic or anaerobic method of composting.
2. Decide what kind of container to use for the compost. See pages 14 to 18 for descriptions. Choose one, or design your own.

Containers for Compost

	Page
Aerobic	
Oil drum	14
Trash can	15
Wire mesh	15
Anaerobic	
Polyethylene plastic sheet	17
Polyethylene plastic bag	18
Trench	18

3. Prepare your containers for compost.
4. Prepare your mix of materials for composting.

   a. Put your raw materials in a pile. Half or more should be freshly cut green plants. Up to a fourth should be manure, which supplies nitrogen to organisms in the pile. (If you can't get manure, make sure to use large amounts of new or young plant growth—cut grass, hedge trimmings—to supply nitrogen.)
   b. Shred all the raw materials by running a lawnmower through the pile several times, until everything is in small pieces. If you can't get a lawnmower, you can chop materials by hand or rent a commercial compost shredder.

CAUTION: Do not do the shredding alone. Get an adult to do it or to supervise you as you do it. Wear hard-top shoes and safety goggles.

Shredding helps the composting process by (1) releasing fluids, (2) breaking down tough tissues, (3) increasing the area of surface on which decay can take place, and (4) controlling moisture. For aerobic composting, shredding helps to aerate the pile and makes it easier to turn the compost.

c. Using a hose or a sprinkling can, mix the materials thoroughly with water. If your compost pile is too wet or too dry, it won't decompose properly.

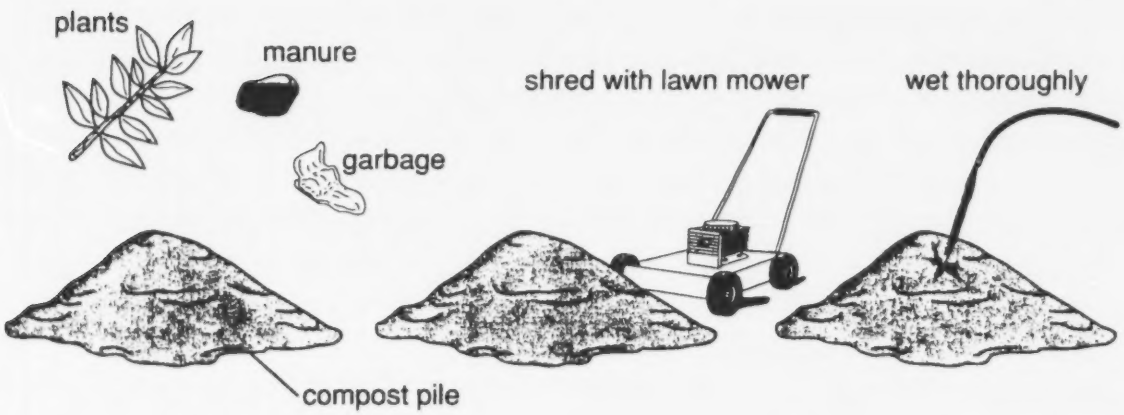

Figure 1 Procedure for making a compost pile

5. Estimate the volume of the compost pile in cubic meters and record it.

   (Later you will compare the volume of the pile with the volume of the decomposed matter.)

   The volume of the pile is crucial to decomposition. If it is less than .15 to .20 cubic meters (35 to 50 gallons), the materials may not decompose properly. Use these formulas to estimate the volume of your pile:

Gallons	x	0.004	=	cubic meters
Cubic feet	x	0.028	=	cubic meters
Cubic yards	x	0.765	=	cubic meters

6. Put the composting materials into your container.
7. Every day, measure the temperature of the pile by inserting a thermometer about 20 to 25 centimeters into the pile. Record the readings and graph them. See Figure 2 on the next page.

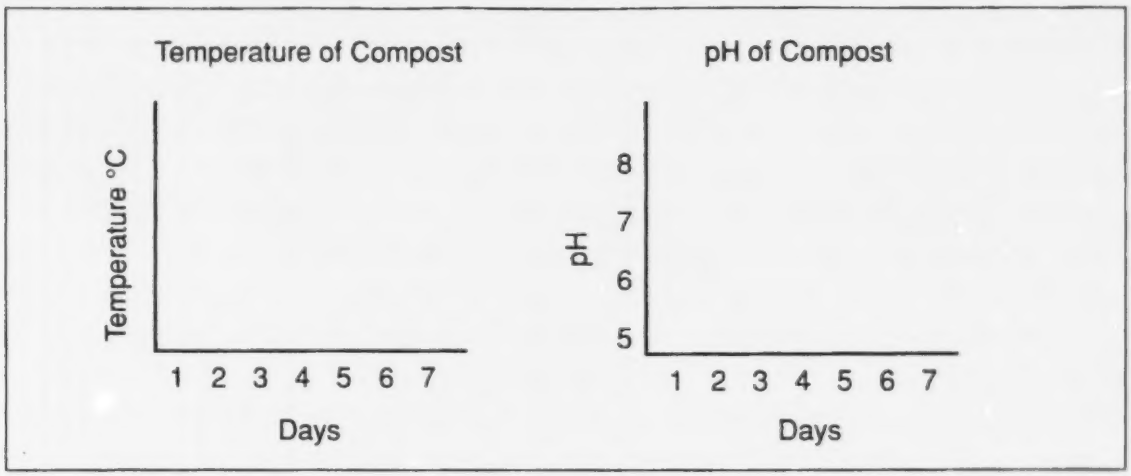

Figure 2 Graph for temperature and pH data

If the temperature doesn't reach 45°C to 60°C within 3 days, the pile has too little water, manure, or green plant material. Mix more green plant material into the pile and wet it to start decomposition.

8. Every day, monitor the pH of the pile by testing with pH paper, which measures the acidity of liquids. You'll compare the color of wet pH paper with a chart to get a numerical reading. Numbers 1 to 6 indicate an *acid*, with pH 1 being most acidic. Distilled water has a pH of 7, which is *neutral*. A pH between 8 and 14 is *alkaline*.

    a. Take a small sample of compost from the center of the pile and mix it with a few drops of water.
    b. Dip a glass rod into the solution and then touch the wet rod to a piece of pH paper. Compare the color with the pH scale.
    c. Record and graph the readings. See Figure 2 on this page.

    If your pH reading falls between 6.5 and 8.0, you'll know that organisms are at work decomposing the materials. If the pH falls, the organisms are dying. A pH of 5 or less means they are probably dead.

    To restart decomposition, aerate the pile and add fresh green plants.

Studying the Decomposition Process

If you are going to study the process of decomposition, prepare the following materials to compare with finished compost later.

Materials

- small jars (baby-food size) with lids
- 2 or 3 strips of linen
- two 1-gallon jars
- pinch clamps
- two #4 one-hole rubber stoppers
- 2 thermometers
- short piece of rubber tubing
- bits of metal or foil

Directions

1. Put samples of composting materials in two of the small jars; put a piece of metal or foil in the other jar as shown in Figure 3. Close the jars tight. (Later you will compare these samples with samples of the finished compost.)

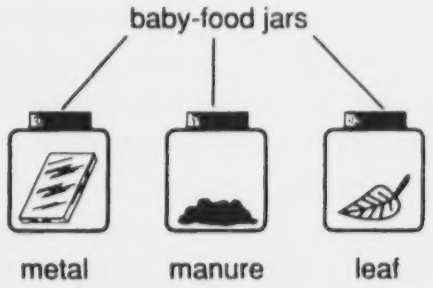

Figure 3 Small jars of compost materials

2. Fill the gallon jars with wet, mixed compost. Fit each jar with a gas vent and a thermometer as shown in Figure 4. Keep the jars sealed tight. Measure and record the temperature every 2 days. (Later you will use these samples to compare with compost from your pile.)

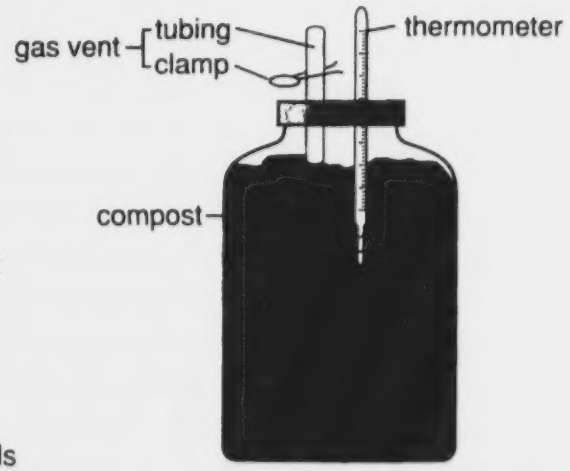

Figure 4 Gallon jar of compost materials

3. Enclose sample materials and a strip of linen in mesh screen.

   a. Make some packets from mesh screen. See Figure 5.
   b. Put strips of linen in some of the packets.
   c. Put other materials such as plant or animal matter and metal or foil into other packets.
   d. Bury the packets in the compost pile.

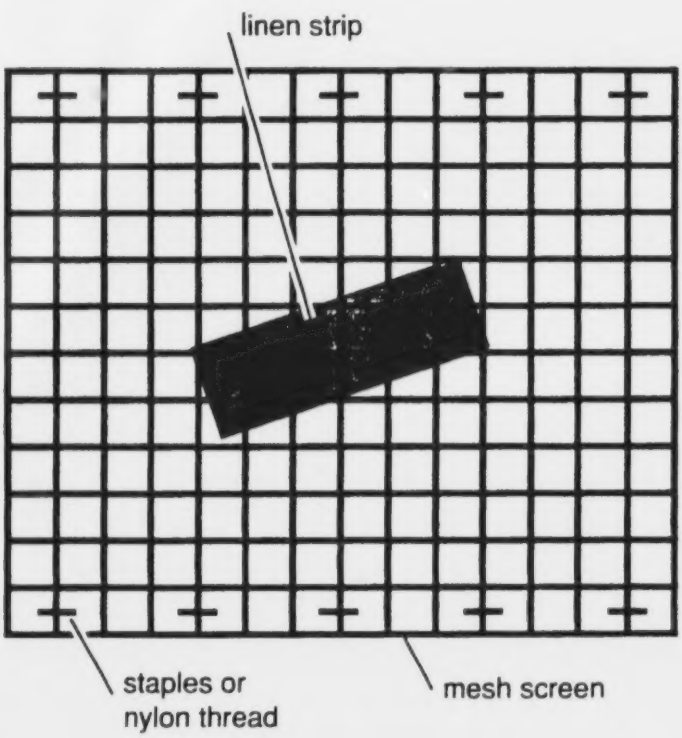

Figure 5 Materials enclosed in mesh screen

Later you can retrieve the strips of linen from the pile and test them for amino acids. You can examine the other materials for evidence of decomposition or resistance to it.

Containers for Aerobic Decomposition

Containers for aerobic decomposition must be large enough to hold at least .15 cubic meters (about 35 gallons). They should have many holes in the sides and the bottom to let air circulate, and they should allow for easy turning of the compost.

Oil-Drum Container

Oil drums are not too hard to get, and they hold enough material to decompose readily. You'll have to punch holes in the drums for air; take care not to cut yourself on sharp edges.

1. Get two or more 55-gallon oil drums. If they have lids, remove them.
2. With a pick or chisel, punch holes 2 to 3 centimeters in diameter in the bottom and sides of each drum. Flatten rough edges with a hammer.
3. Set the drums on bricks or blocks or stones so that air can circulate freely through the compost.

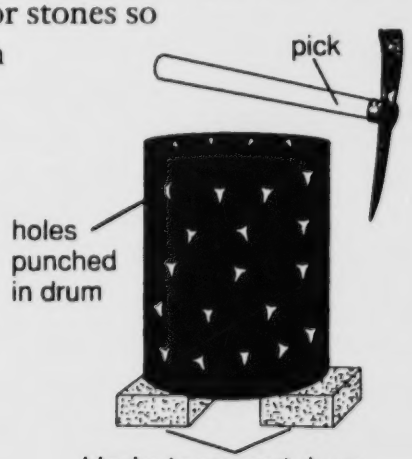

Figure 6 Oil-drum container

Trash-Can Container

These containers, made from plastic trash cans, are lightweight and will have no sharp edges around the holes. Try to get trash cans larger than 30 gallons—the minimum volume for proper decomposition; they yield better compost than 30-gallon cans do.

1. Get two or more plastic trash cans with a capacity of 30 gallons or more.
2. Drill holes in the bottoms, sides, and tops of the cans.
3. Set the cans on bricks or blocks or stones so that air can circulate freely through the compost.

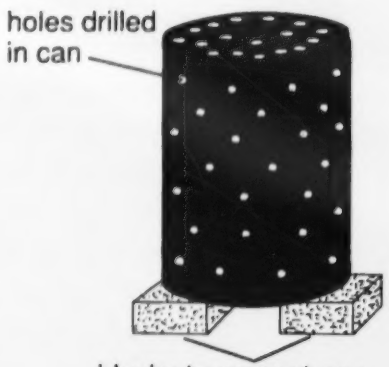

Figure 7 Trash-can container

Wire-Basket Container

A wire basket is easy to remove for turning the compost, and it allows maximum circulation of air. A disadvantage is that the compost may dry out too quickly.

1. Get a 3 x 6-foot section of wire fencing.
2. Bend the wire in the shape of a cylinder and fasten the ends together with wire or metal clips. See Figure 8 below and Figure 9 on the next page.

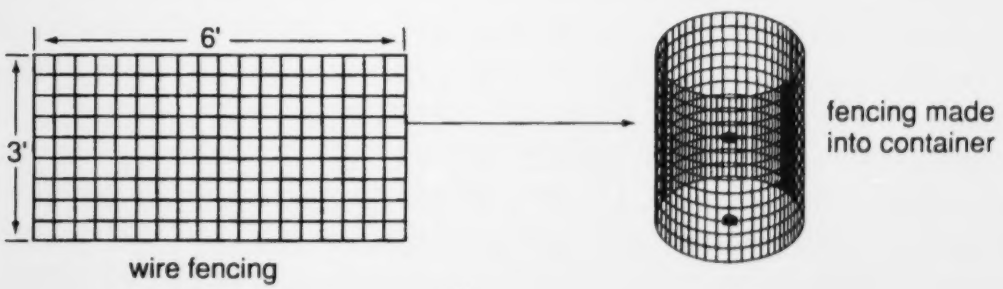

Figure 8 Wire container

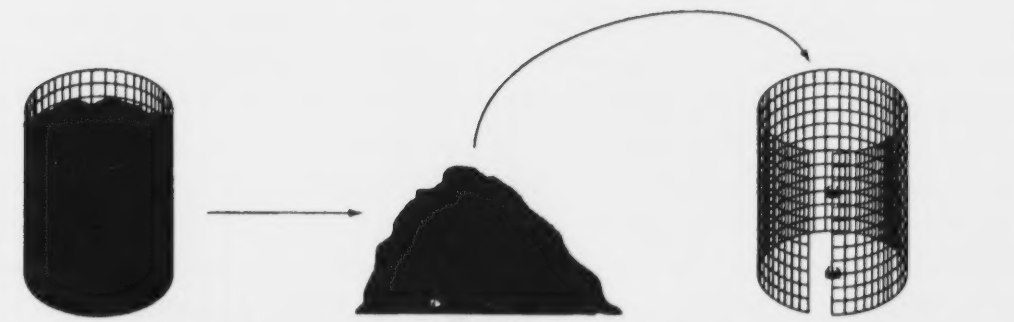

Figure 9 Wire container filled with compost

Using Containers for Aerobic Decomposition

1. Fill the container with wet, shredded composting materials.
2. Cover the compost materials with wet burlap or a lid with holes to keep most rain out but let air circulate through the compost.
3. Every 2 days, open the container and lift out the materials a forkful at a time to aerate the decomposing materials. Put the turned material back in the container.

Twenty-one days is the average time to produce finished compost by aerobic decomposition. The compost is ready when its temperature reaches the temperature of the ambient air.

Containers for Anaerobic Decomposition

For anaerobic (airless) decomposition, any airtight container that holds .15 cubic meters (about 35 gallons) or more will do. See the next sections for other ways to decompose your materials.

Polyethylene Plastic Sheet

1. Put your wet, shredded composting materials in a pile or a hole in the ground.
2. Cover the pile with heavy plastic. See Figure 10.
3. To hold the plastic sheet in place and keep air out of the pile, anchor the plastic all around with a layer of soil.

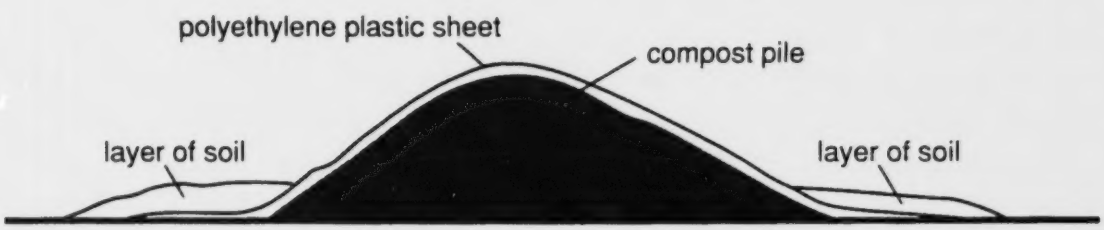

Figure 10 Polyethylene sheet to cover compost

4. Wait 3 to 4 months. Then uncover a corner of the plastic sheet and smell the mixture.

   If it smells putrid, decomposition is incomplete. Cover the pile again and wait. If the pile has little or no odor, the compost is ready to use.

Polyethylene Plastic Bag

1. Depending on how much compost you want to make, get one or more 30-gallon plastic garbage bags.
2. Fill the bag with wet, shredded composting materials. Take care not to puncture the bag.
3. Seal the bag to keep it airtight. See Figure 11.
4. After 3 to 4 months, open the bag.

   If the mixture smells putrid, decomposition is incomplete. Seal the bag and wait. If the mixture has little or no odor, the compost is ready to use.

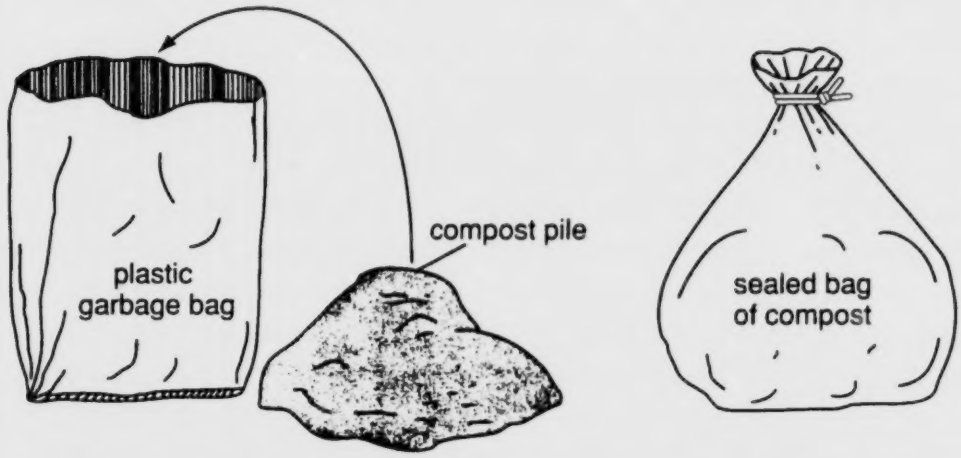

Figure 11 Polyethylene bag used as a container

Trench

1. Dig a trench 30 to 50 centimeters deep.
2. Put your wet, shredded composting materials in the trench.
3. Cover the composting materials with a layer of soil about 15 centimeters deep. See Figure 12 on the next page.
4. After 3 or 4 months, you can plant seeds on top of the trench. The roots will grow down into the compost.

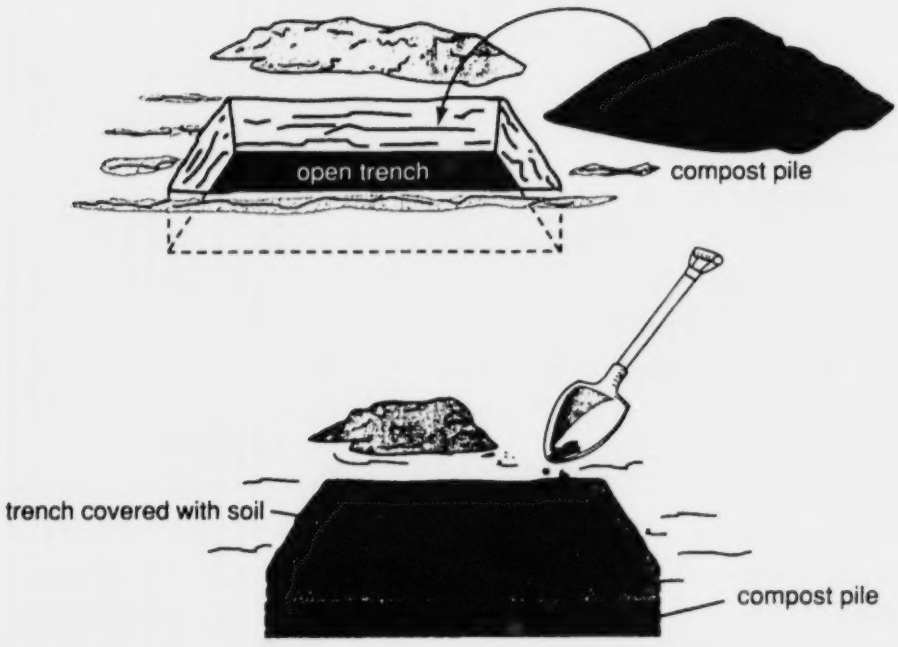

Figure 12 Trench burial of compost

The Process of Aerobic Decomposition

Because aerobic decomposition is a fairly speedy way of recycling solid wastes, scientists and engineers have studied it thoroughly during the past few decades as a method of managing solid waste disposal in cities. Hence we know more about aerobic decomposition than we do about anaerobic decomposition.

An aerobic compost pile, prepared properly, is an ideal environment where decay-causing bacteria and other organisms can thrive and reproduce.

The first thing that happens in a compost pile is that nitrogen substances rapidly combine with oxygen, producing heat and a large quantity of new nitrogen compounds, mostly ammonia.

Next, living organisms begin to decompose the raw materials, using carbon compounds as their energy source. In the process, they release heat, quickly raising the temperature in the pile to a range between 45°C and 70°C. The temperature remains constant for 3 or 4 days, allowing heat-loving *(thermophilic)* bacteria to decompose the materials.

If the pile doesn't reach a high temperature in 3 to 6 days, the cause may be that the pile is (1) too small to retain heat, (2) too dry or too wet, or (3) too low in nutrients to keep decomposition going. In such cases you may have to restart the compost pile. Turning the compost every other day aerates the pile and exposes weed seeds and disease organisms to high temperatures that kill them.

In 4 or 5 days, the temperature slowly falls to 40°C or 45°C. Now mid-temperature-loving *(mesophilic)* organisms, both bacteria and fungi, take over the work of decomposing substances in the pile. As they become less active, the pile loses more heat than they create. As the temperature of the pile falls, its volume drops.

If the volume of the heap doesn't drop in about a week, either the aeration is poor or the pile is too dry. When the temperature reaches 25°C to 30°C, the process is complete.

Figure 13 below shows a typical temperature curve for aerobic decomposition. The numbers on the curve match these steps in the decomposing process:

1. As chemical oxidation proceeds, the temperature rises in the pile.
2. Aerobic fungi acting in the pile release nitrogen compounds, and the temperature keeps rising.
3. At high temperatures (60°C to 75°C), aerobic bacteria become active; other organisms have died, are dormant, or have left the pile.
4. Anaerobic bacteria work mostly in the middle of the pile, and the temperature falls.
5. Nitrogen-fixing bacteria, *Azobacter*, combine nitrogen from the air with other substances, increasing the amount of nitrogen in the compost. Other organisms, such as insect larvae, insects, and fungi, are further decomposing substances in the pile; temperature is falling until it reaches the temperature of the surrounding air.

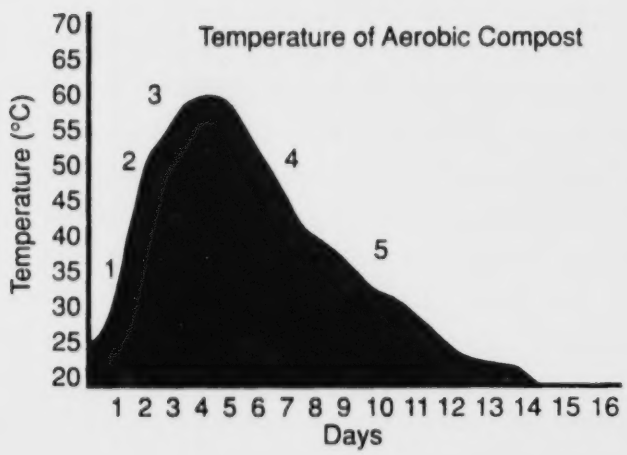

Figure 13 Temperature change in aerobic compost pile

The Process of Anaerobic Decomposition

In anaerobic decomposition, plant and animal matter breaks down in an airless environment. Anaerobic decomposition is much slower than aerobic decomposition, and it gives off a strong, unpleasant odor. We know much less about anaerobic processes than we do about aerobic processes. (In aerobic decomposition, if the pile of compost gets so wet as to close out air, anaerobic decomposition will begin.)

Anaerobic decomposition has one advantage over aerobic decomposition: the compost retains more of the nutrients. Closing off the air supply to the pile creates an environment from which little nitrogen is lost. The most common method of anaerobic composting is to use polyethylene plastic bags or sheets to keep air out of the mixture.

But anaerobic decomposition is slow. Because fewer kinds of organisms can live under airless conditions, the process can take 3 to 4 months to complete. See Figure 14, which shows the temperature curve in an anaerobic pile.

In an anaerobic pile, bacteria and yeasts do most of the decomposing work. The lack of air kills off any weed seeds in the pile.

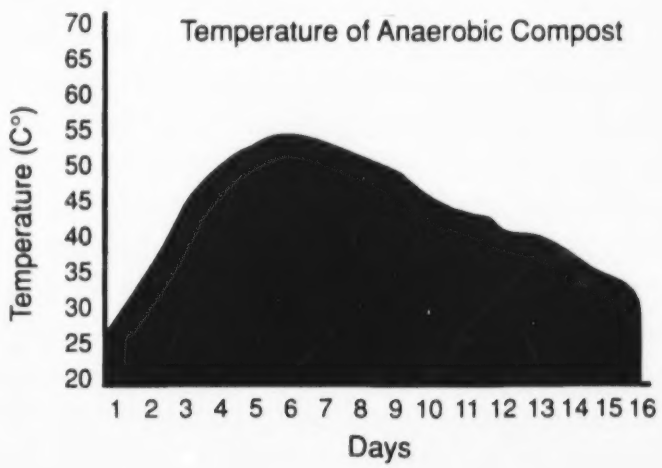

Figure 14 Temperature change in anaerobic compost pile

A Bird That Uses Compost

In the dry eucalyptus thickets of Australia's southern outback lives the mallee fowl, a most astonishing bird. It is a *megapod*—a big-footed bird. The mallee, about the size of a chicken, looks something like a pheasant or a partridge. It uses a most ingenious method of incubating its eggs. The male builds a huge mound, up to 3 meters wide and 1.5 meters high, from soil and leaf litter. In the spring he digs a crater in the center of the mound and deposits leaves and bark he collected in the winter.

When the rain comes, the leaves and bark soak up water and begin to decompose, and the temperature rises. Soil and sand keep the heat in the mound. When the center of the mound reaches the right temperature, the female lays her eggs and covers them with the leaves. She lays an egg every 4 to 8 days, as many as 12 to 30 in a season.

She goes off to search for food to keep up her egg production while the male tends the mound for much of the year. Although mallees mate for life, they spend little time together because the female keeps busy foraging and the male keeps busy tending the mound.

Once or twice a day the male tests the temperature in the mound with his tongue. For the whole incubation season he keeps the temperature within 1 degree of 33°C by removing or adding materials. He uncovers the mound to let in solar heat and then re-covers it to retain warmth overnight. Each day he moves about a half-ton of earth, using only his feet.

The eggs hatch in 7 to 9 weeks. Then the chicks dig themselves out of the mound, already fully feathered. Off they go to forage, and within 24 hours they are on their own and able to fly.

Each year the parents return to the nest and repair it for the next incubation.

Sadly, the mallee fowl is now an endangered species. As the scrub is cleared for farming, they are vulnerable to attacks by foxes, hawks, dingoes, and feral cats.

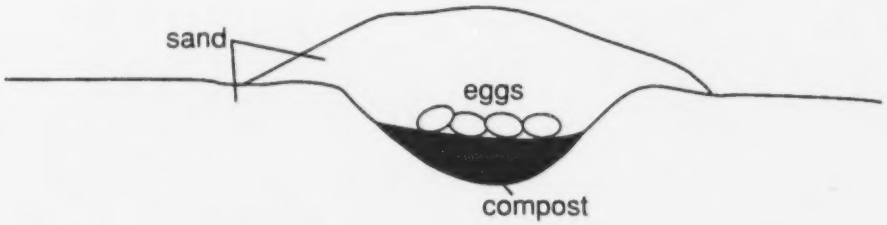

Figure 15 Mallee fowl nest and compost

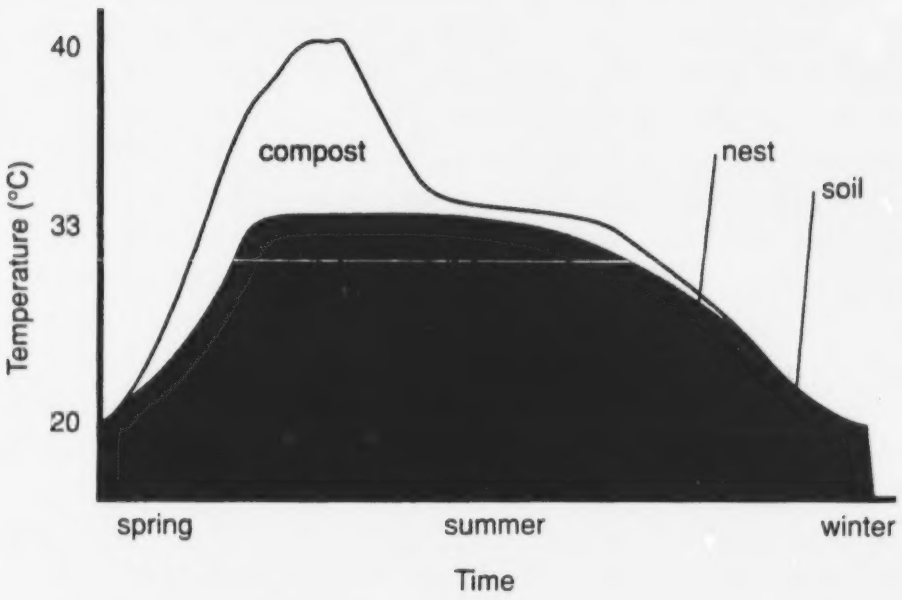

Figure 16 Temperature relationships of mallee fowl nest

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